DETERMINING EARLY FAILURE OF ROOT DISEASED INCENSE-CEDARS IN YOSEMITE VALLEY

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By

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INTRODUCTION

The forest trees of Yosemite Valley are predominantly ponderosa pine, incense-cedar, and black oak, with a scattering of white fir, Douglas-fir, Jeffrey pine, and miscellaneous hardwoods. The conifers form an 80 to 100 year old even-aged stand that became established in the valley when man began controlling fires and allowing livestock to overgraze the valley meadows.

Uprooted and windthrown conifers have been a continuing problem in the valley. Tree failures have been frequent, and buildings, autos, powerlines, and other property have been damaged.

In the 1960's, Forest Service pathologists discovered the root disease fungus, *Fomes annosus,* in the roots of windthrown trees. Further discoveries of root disease centers in the valley led the Park Superintendent, in 1971, to request an evaluation of the problem. The evaluation was conducted by the Forest Insect and Disease Management Staff, Forest Service, California Region, in cooperation with pathologists from the Department of Plant Pathology, University of California, Berkeley.

Over 100 infection centers were confirmed in developed sites. New centers have been found each year since the evaluation was begun in 1971, and it is likely that more will be discovered in the future.

Because developed sites contain many infection centers, with root-rotted trees a potential danger to people and property, there is a need to identify hazardous trees.

This guide is designed to enable tree inspectors in Yosemite Valley to identify root-decayed incense-cedars so they may be removed before they fall.

Guidelines were developed by uprooting 59 incense-cedars and comparing the amount of root decay with the condition of the crown. Factor analysis and stepwise multiple regression were used to determine the combination of crown factors that best reflected the amount of root decay.

The potential for early failure is only an estimate with a very broad range. However, the index correctly estimated the root decay class of 80% of the 59 sample trees.

CROWN SYMPTOMS OF ROOT DECAYED INCENSE-CEDAR

When an incense-cedar becomes infected with a root decay fungus such as *Fomes annosus,* symptoms are expressed in the crown of the tree. Initially, the crown starts losing its interior foliage, usually starting in the lower part of the crown (Fig. 1). As this is occurring, secondary and tertiary branches start to die. These dead and dying branches may be scattered throughout the crown, but most will be in the lower part of the crown (Fig. 2).

As the crown declines, the lower primary branches start to die; the foliage in the interior of the upper part of the crown becomes thinner; the death of secondary and tertiary branches increases; and primary branch mortality continues to move upward, reducing the size of the live crown (Fig. 3).

Gradually the crown takes on a thin, lacy appearance, with foliage remaining only on the tips of the branches (Fig. 4).

At some point in this process, the top of the crown changes from a pointed, conical shape (indicative of a vigorously growing incense-cedar), to a rounded and then flat top, as the growth rate of the tree declines (Fig. 5).

FIGURE 1. *Initially, the crown starts losing interior foliage, usually starting in the lower part of the crown. Note the thin interior foliage just above the dead branches.*

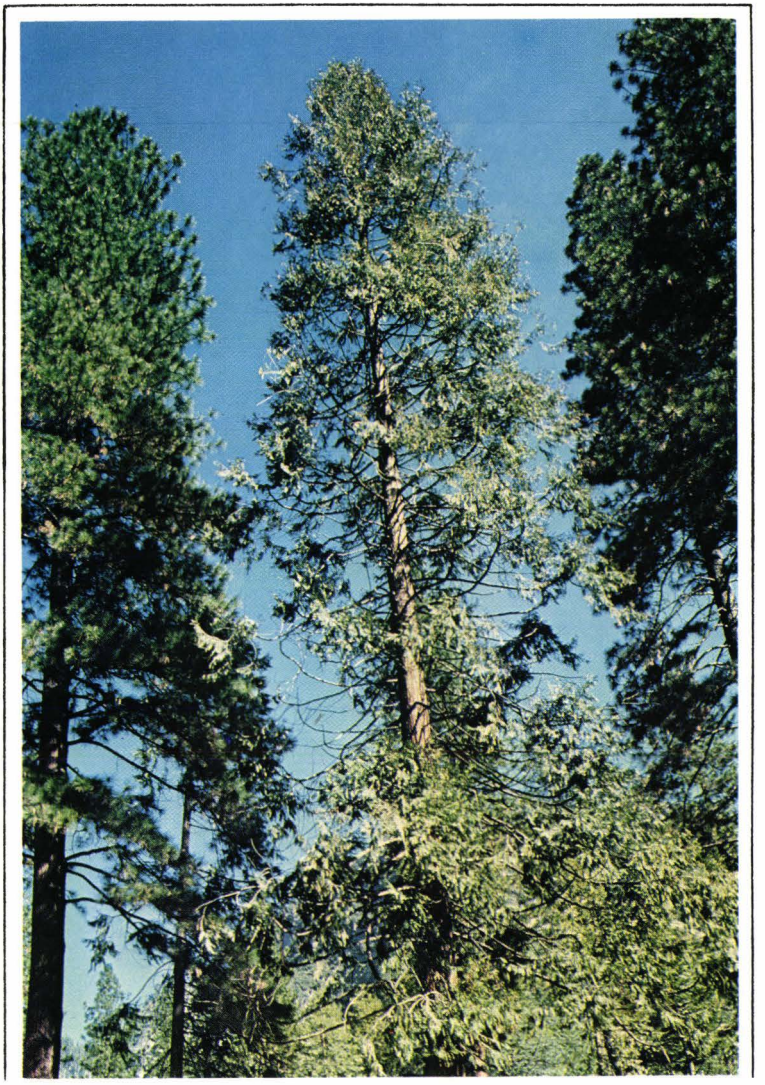


FIGURE 2. *As the crown loses its foliage, the secondary and tertiary branches start to die.*

FIGURE 3. *Death of the primary branches reducing the size of the live crown.*

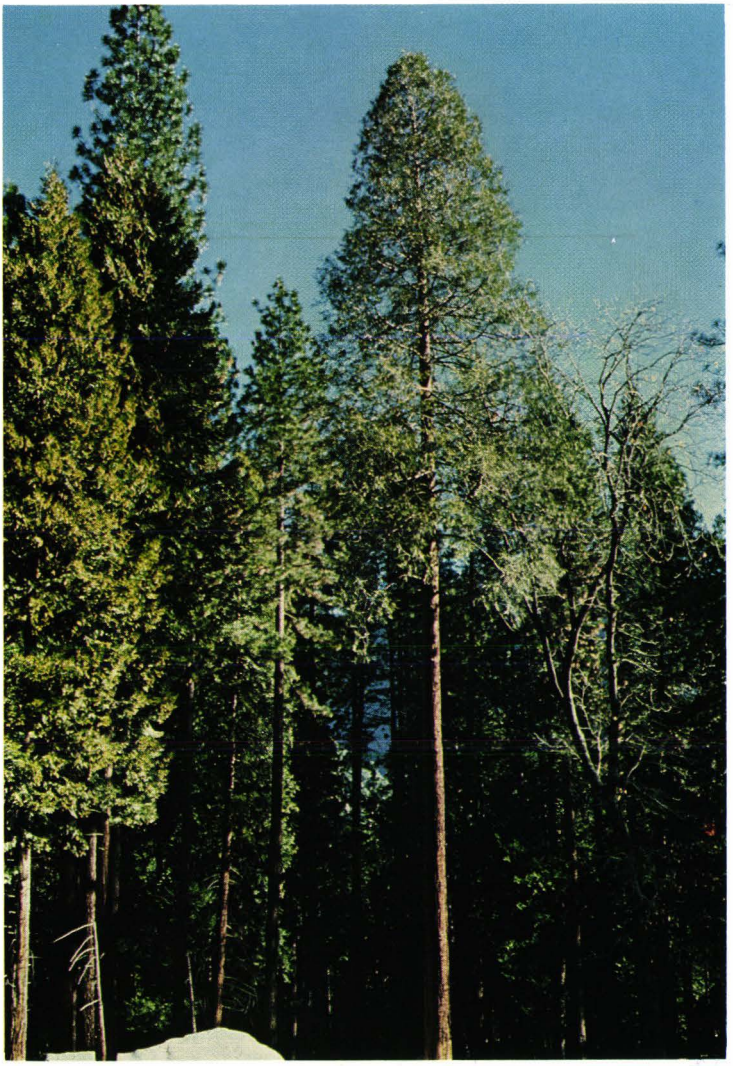


FIGURE 4. *Incense-cedar crown exhibiting thin, lacy appearance.*

FIGURE 5. *The top of the crown of this incense-cedar is flat, a characteristic commonly associated with declining trees.*

DETERMINING POTENTIAL FOR EARLY FAILURE

Potential for early failure is based on an estimate of the amount of decay in supporting roots, as indicated by crown characteristics. Four classes of root decay are recognized: None, low, moderate and high.

Three crown characteristics influenced by root decay are: 1) percent live crown, 2) crown vigor, and 3) crown top shape. These characteristics are rated as defined below:

a) *Percent Live Crown:* This is the amount of the total crown that has live limbs (Fig. 6). If a tree has 80 feet of crown, of which 40 feet has live limbs, the percent live crown is 50.

An estimate to the nearest 10 percent is adequate. No precision instruments such as clinometers or abneys are necessary.

b) *Crown Vigor:* This is a measure of the condition of the live crown as indicated by the loss of interior foliage and the dying of secondary and tertiary limbs.

A live crown has four possible vigor ratings:

	Vigor Rating	
1) Healthy crown: No indication of decline.	4	(Fig. 7)
2) Lower ⅓ of the crown declining.	3	(Fig. 8)
3) Lower ⅔ of the crown declining.	2	(Fig. 9)
4) Whole crown declining.	1	(Fig. 10)

c) *Crown Top Shape:* This is the silhouette of the top of the crown at the time of the evaluation.

	Top Shape Rating
1) Fig. 11	3
2) Fig. 12	2
3) Fig. 13	1

The ratings are then entered into the following equation to determine the trees potential for early failure:

Potential for Early Failure
$= 6.5 - .02a - .58b - .45c$

Where 6.5 = constant
a = percent live crown
b = crown vigor
c = crown top shape

Potential for early failure (Table 1) is based on an estimate of the amount of decay in supporting roots, as indicated by crown characteristics. If the potential for early failure is 0 to .99 the estimated amount of decayed support roots is 0 (Class:None); 1 to 2.99 the estimated amount decayed support root is 1 - 40 percent (Class:Low); 3 to 3.99, the estimated amount of decayed support root is 41 - 80 percent (Class:Moderate); 4 or greater, the estimated amount of decayed support root is 81 - 100 percent (Class:High).

TABLE 1

Potential for Early Failure	*Estimate of Amount of Decayed Support Roots*	*Class*
0 - .99	0	None
1 - 2.99	1 - 40%	Low
3 - 3.99	41 - 80%	Moderate
4 - 6.50	81 - 100%	High

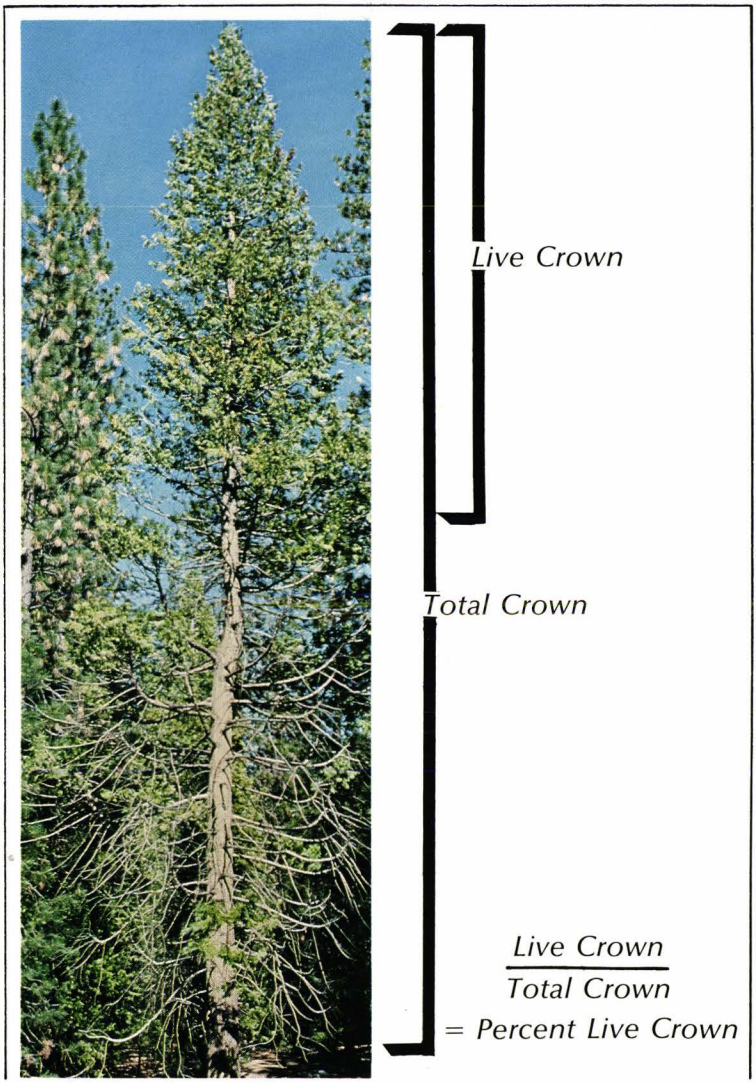


FIGURE 6. *Percent Live Crown*
This can be visually estimated to the nearest 10%. Be sure to include the scattered dead branches in the live part of the crown in the estimates.

FIGURE 7. *Crown Vigor 4: Healthy crown: No indication of decline.*

FIGURE 8. *Crown Vigor 3: Lower ⅓ of the crown declining.*

FIGURE 9. *Crown Vigor 2: Lower ⅔ of the crown declining.*

FIGURE 10. *Crown Vigor 1: Whole crown declining.*

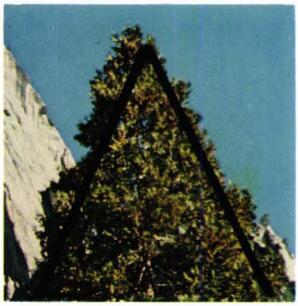


FIGURE 11a. *An example of top shape rating 3.*

FIGURE 12a. *An example of top shape rating 2.*

FIGURE 13a. *An example of top shape rating 1.*

EXAMPLES OF TREES EXAMINED

The following are examples of trees that were evaluated on the basis of the three crown characteristics described above and then pulled over to determine the percent of the major support roots that were decayed. Each picture is accompanied by an illustration, crown characteristic ratings, decay class and percent root decay. The schematic illustrations are present so that the crown details of each tree, which may be obscured by the vegetation surrounding the tree in the picture, can be examined in relation to the crown characteristic ratings.

To simplify the calculations for field use, there are three tables following. To use these tables, simply rate each characteristic, obtain the factor for each rating from the respective table, add these factors together and subtract the total from 6.5 to calculate the potential for early failure.

TABLE 2

LIVE CROWN RATIO

Percent	*Factor (.02a)*
10	.20
20	.40
30	.60
40	.80
50	1.00
60	1.20
70	1.40
80	1.60
90	1.80
100	2.00

TABLE 3

CROWN VIGOR

Rating	*Factor (.58b)*
1	0.58
2	1.16
3	1.74
4	2.32

TABLE 4

CROWN TOP SHAPE

Rating	*Factor (.45c)*
1	0.45
2	0.90
3	1.35

FIGURE 14a

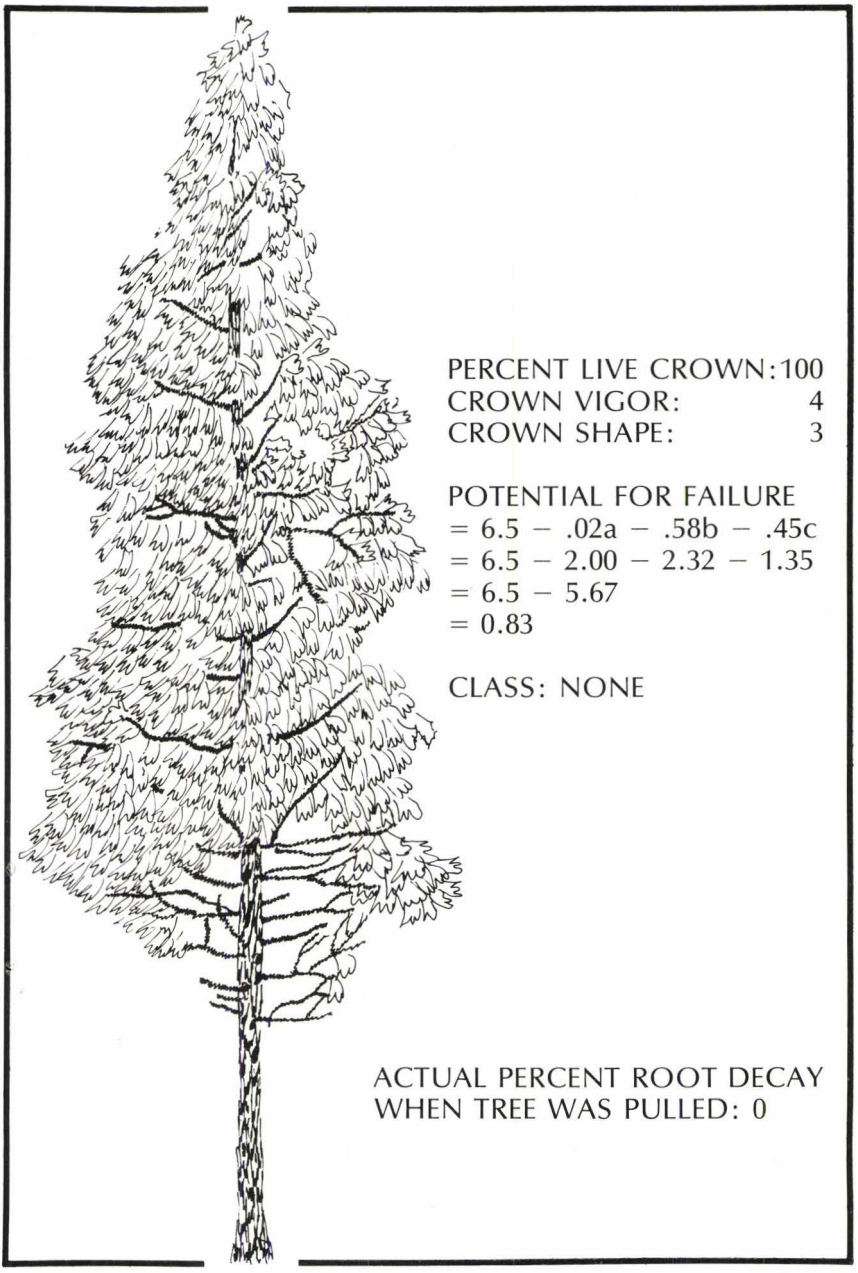

PERCENT LIVE CROWN: 100
CROWN VIGOR: 4
CROWN SHAPE: 3
POTENTIAL FOR FAILURE
= 6.5 − .02a − .58b − .45c
= 6.5 − 2.00 − 2.32 − 1.35
= 6.5 − 5.67
= 0.83
CLASS: NONE
ACTUAL PERCENT ROOT DECAY
WHEN TREE WAS PULLED: 0

FIGURE 14b

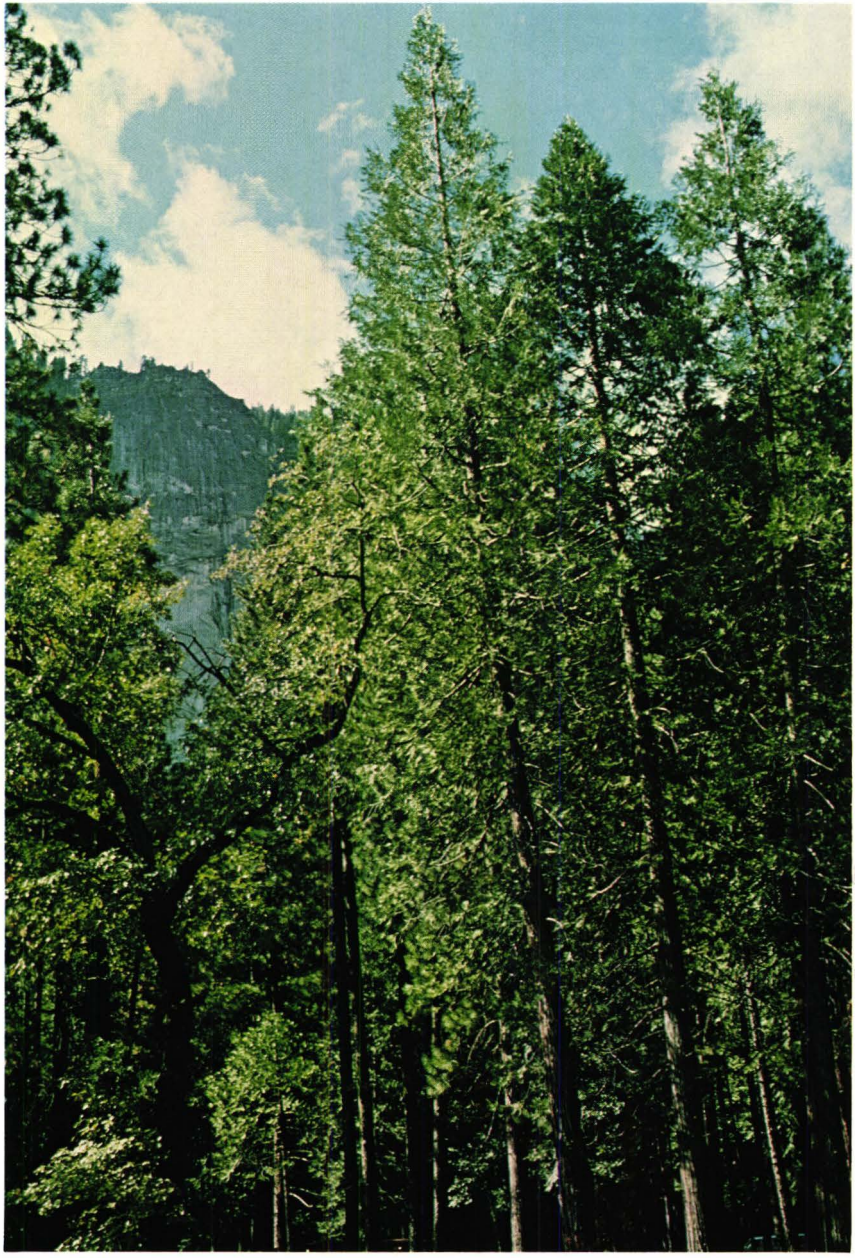
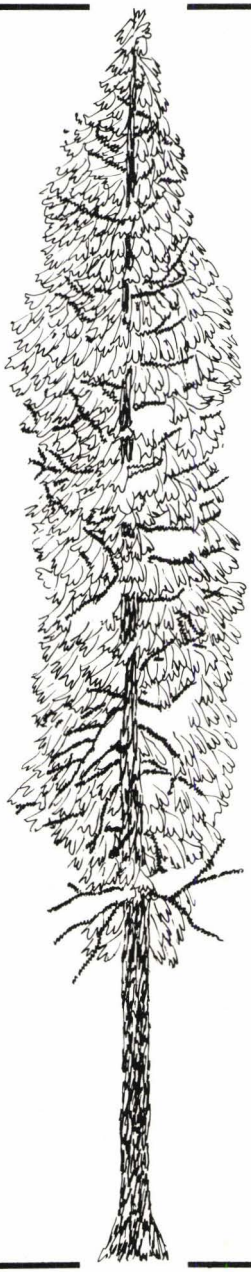


FIGURE 15a



PERCENT LIVE CROWN: 90
CROWN VIGOR: 2
CROWN SHAPE: 3

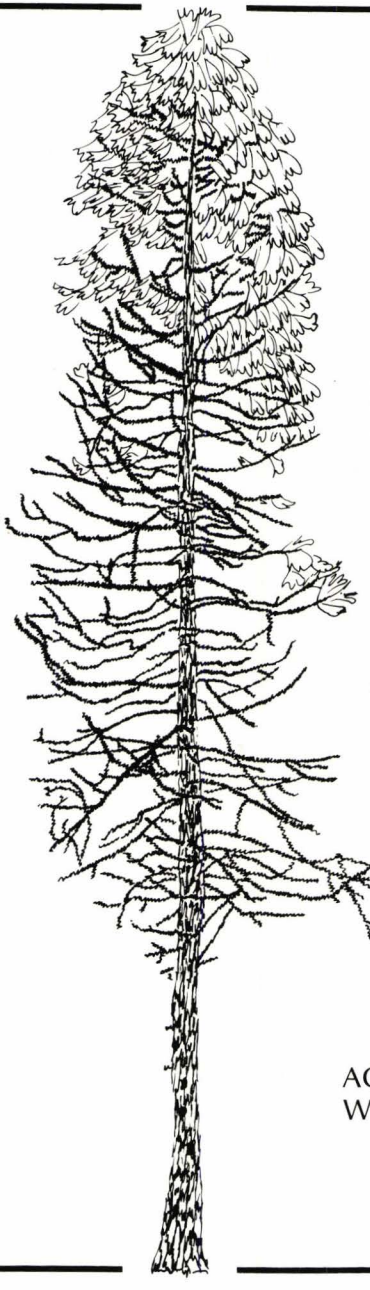
POTENTIAL FOR FAILURE
= 6.5 − 0.2a − .58b − .45c
= 6.5 − 1.80 − 1.16 − 1.35
= 6.5 − 4.31
= 2.19

CLASS: LOW

ACTUAL PERCENT ROOT DECAY
WHEN TREE WAS PULLED: 13%

FIGURE 15b

FIGURE 16a



PERCENT LIVE CROWN: 40
CROWN VIGOR: 2
CROWN SHAPE: 2

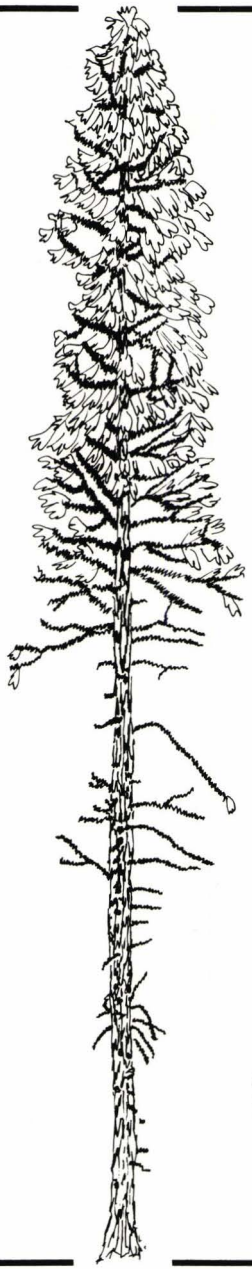
POTENTIAL FOR FAILURE
= 6.5 − .02a − .58b − .45c
= 6.5 − .80 − 1.16 − 0.90
= 6.5 − 2.86
= 3.64

CLASS: MODERATE

ACTUAL PERCENT ROOT DECAY
WHEN TREE WAS PULLED: 60%

FIGURE 16b

FIGURE 17a



PERCENT LIVE CROWN: 50
CROWN VIGOR: 1
CROWN TOP SHAPE: 3

POTENTIAL FOR FAILURE
= 6.5 − .02a − .58b − .45c
= 6.5 − 1.00 − 0.58 − 1.35
= 6.5 − 2.93
= 3.57

CLASS: MODERATE

ACTUAL PERCENT ROOT DECAY
WHEN TREE WAS PULLED: 79%

FIGURE 17b

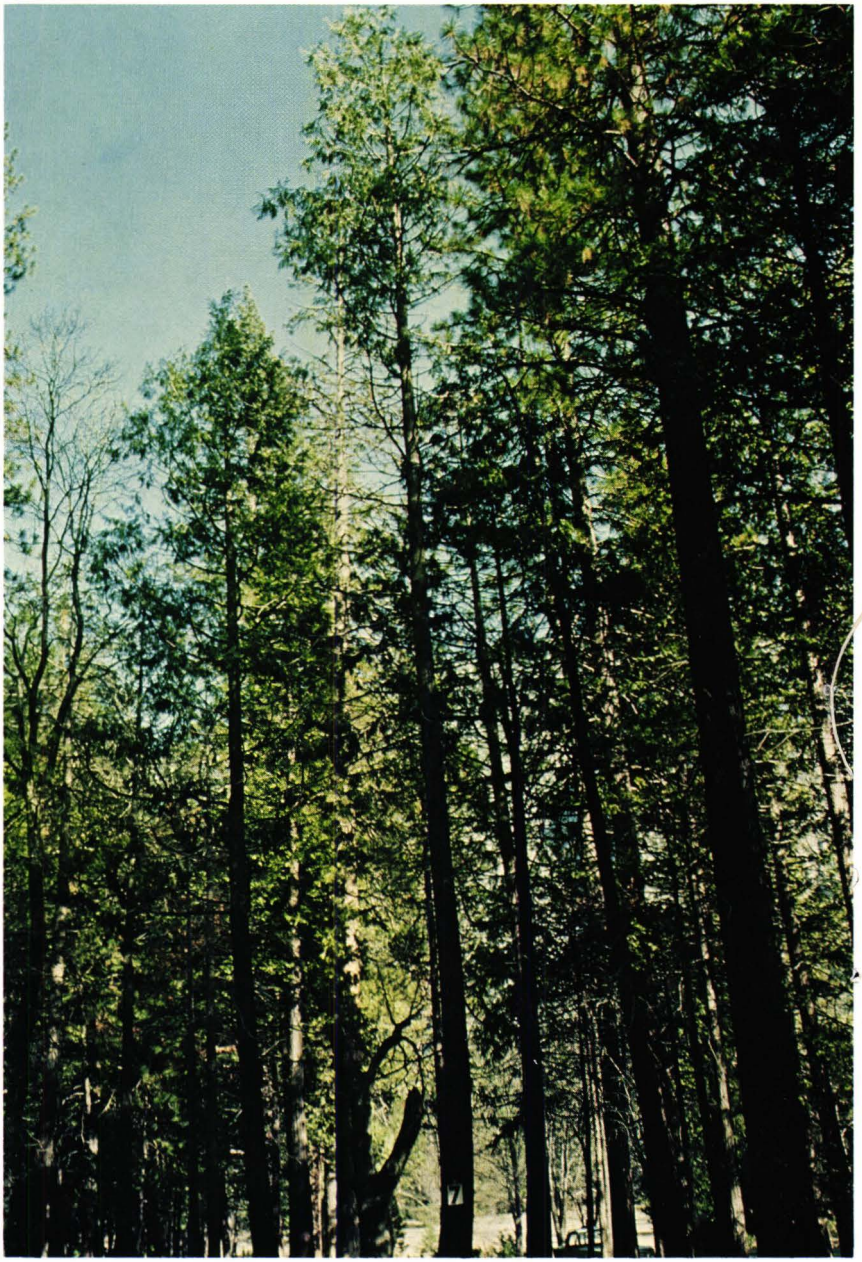
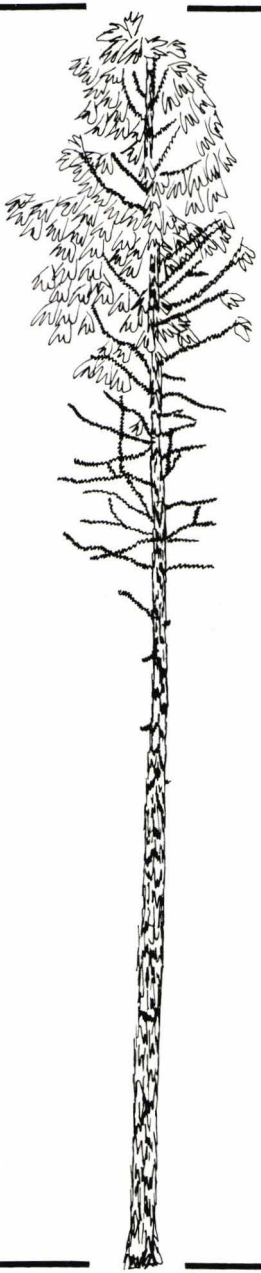


FIGURE 18a



PERCENT LIVE CROWN: 30
CROWN VIGOR: 1
CROWN TOP SHAPE: 1

POTENTIAL FOR FAILURE
= 6.5 − .02a − .58b − .45c
= 6.5 − .60 − .58 − .45
= 6.5 − 1.63
= 4.87

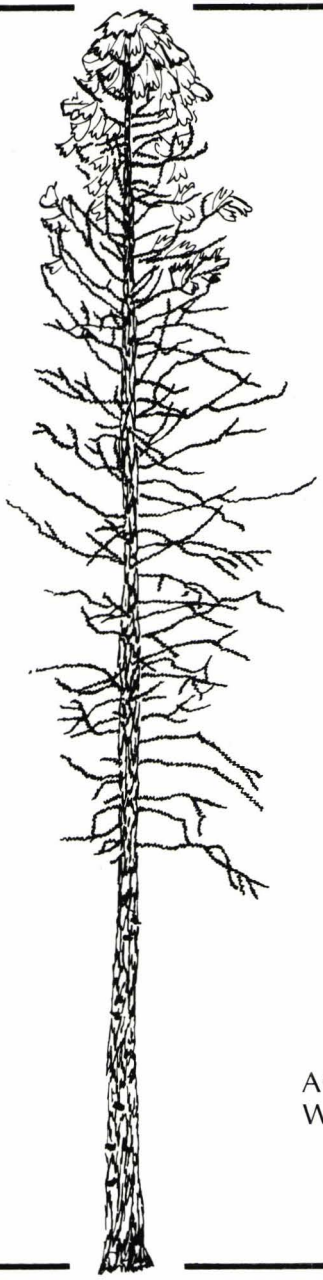
CLASS: HIGH

(The illustration makes the tree appear to have a larger live crown because the dead branches have fallen off the tree.)

ACTUAL PERCENT ROOT DECAY WHEN TREE WAS PULLED: 100%

FIGURE 18b

FIGURE 19a



PERCENT LIVE CROWN: 20
CROWN VIGOR: 1
CROWN TOP SHAPE: 2

POTENTIAL FOR FAILURE
= 6.5 − .02a − .58b − .45c
= 6.5 − .40 − .58 − .90
= 6.5 − 1.88
= 4.62

CLASS: HIGH

ACTUAL PERCENT ROOT DECAY
WHEN TREE WAS PULLED: 90%

FIGURE 19b

OTHER FACTORS TO CONSIDER

When making evaluations for root rotted trees, four additional factors should be considered: 1) stand density, 2) high water table, 3) root disease distribution, and 4) windthrow history.

Stand Density

In situations where trees grow close together, the crown canopy does not allow the sunlight to penetrate into the lower part of the crown. Over a period of time, the lower branches in the crown will decline and die, reducing the size of the live crown, thus producing an appearance similar to that of root rotted trees.

Soil Drainage (Water Table)

A high water table will often keep root systems of trees from fully developing and as a result the crowns have characteristics similar to those produced by crowns of root decayed trees. At the North Pines Campground in Yosemite Valley, there is a group camp parking lot that has a very high water table, especially in the spring. The incense-cedars in this area exhibit symptoms almost identical to those exhibited by root-decayed incense-cedar; however, these trees were so stable that they could not be uprooted with a front-end loader.

Root Disease Distribution

If possible, know the disease history of the area in which the evaluation is to be conducted. When making evaluations, be sure to carefully examine areas of known infection centers.

Windthrow History

There are mortality centers in Yosemite Valley where *Fomes annosus* has not been confirmed, and it is likely that some root disease centers have escaped detection. In areas with a history of windthrow, trees showing crown symptoms should be considered potential failures unless past windthrow has been determined to be caused by some other factor such as shallow rooting in loose soils.

Judgment

This system for rating potential for early failure is not absolute. Those charged with recognizing and removing hazardous trees should consider all factors before reaching a decision. Any declining tree in or at the margin of known *Fomes annosus* (or *Armillarea mellea*) centers should be considered to have decayed roots regardless of stand density, high water table, or other extenuating circumstances. Where root disease has not yet been detected, as is usually the case with single, declining trees, suppression should be considered if the tree is smaller than surrounding trees and in a position to suffer from competition. If however, a single declining tree occupies a dominant position in the canopy, root disease may be more likely to cause decline symptoms than would suppression. Compact groups of declining trees are more likely to be associated with root decay than are single trees.

Careful observations and systematic records on all trees removed or windthrown will allow future refinement of evaluation criteria and skill in recognition of trees which have lost supporting roots to decay. Aside from the value to disease control programs and recreational site selection, recognition of diseased trees and estimation of loss of supporting roots provide a better basis for judging probability of tree failure. This latter is an essential step in estimating hazard when the tree is in a position to cause injuries or economic loss as it fails.

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